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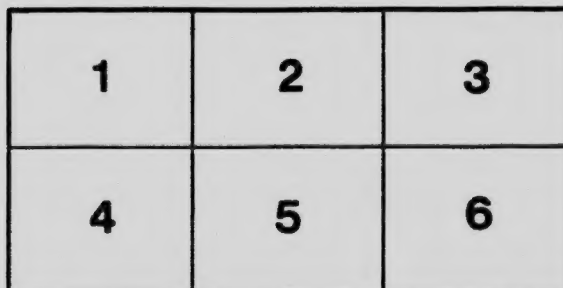
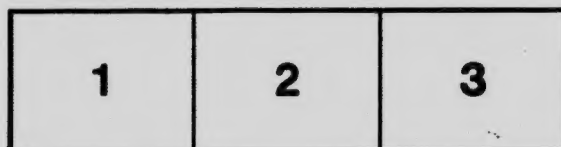
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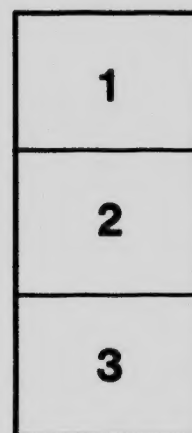
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DEPARTMENT OF AGRICULTURE

CENTRAL EXPERIMENTAL FARM
OTTAWA, CANADA

THE GRADES OF WHEAT

IN THE
MANITOBA INSPECTION DIVISION
CROP OF 1907

PART I

BY

Chas. E. Saunders, Ph. D.,
Cerealist

PART II

BY

Frank T. Shutt, M.A.,
Chemist of the Dominion Experimental Farms

BULLETIN No. 60

APRIL, 1908

Published by direction of the Hon. SYDNEY A. FISHER, Minister of Agriculture, Ottawa.

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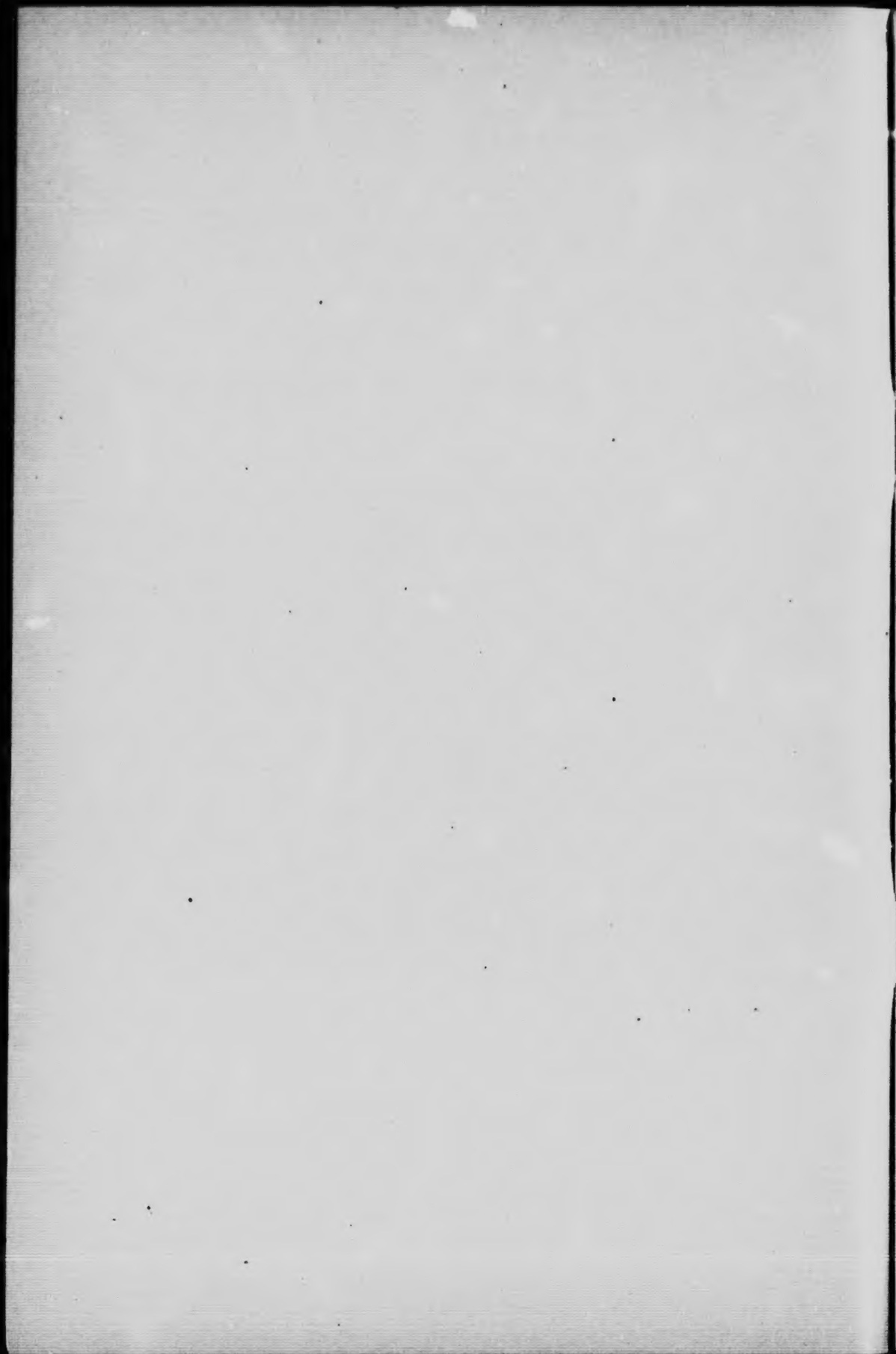
Frank T. Shutt, M.A.,
Chemist of the Dominion Experimental Farms

BULLETIN No. 60

APRIL, 1908

Published by direction of the Hon. SYDNEY A. FISHER, Minister of Agriculture, Ottawa.

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To the Honourable

THE MINISTER OF AGRICULTURE.

SIR,—I have the honour to submit for your approval Bulletin No. 60 of the Experimental Farm series, on "The Grades of Wheat in the Manitoba Inspection Division Crop of 1907." The first part of this Bulletin "On the Milling and Baking Qualities of the Grades of Wheat" has been prepared by Dr. Charles E. Saunders, Cerealist. The second part, "A Chemical Study of the Grain and Flour of the Grades of Wheat," has been prepared by the Chemist of the Experimental Farms, Mr. Frank T. Shutt.

Part I. contains descriptions of the samples and particulars in reference to the cleaning and milling of them; also, of the percentage of straight flour made from each. The results of the Baking tests are also given. In Part II. are presented the details of the analyses of the various grades of wheat, both as received and as cleaned for milling. The analyses of the flours are also submitted with much useful information regarding their several constituents.

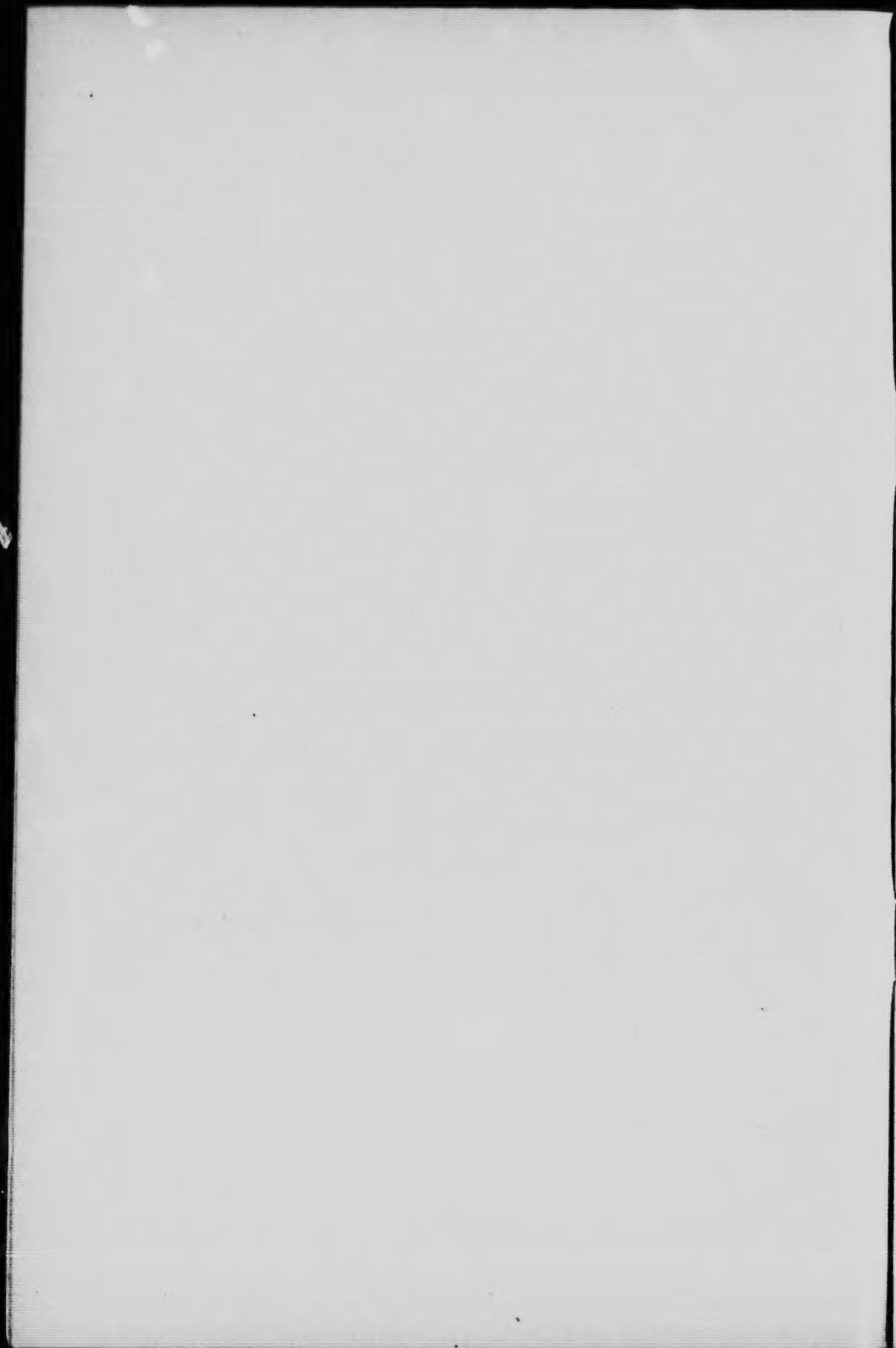
The subject of wheats and their quality, as grown in Canada, is one of much importance to the country, and it is hoped that the information contained in this bulletin concerning the results of the research work done on this important cereal in the laboratories of the Central Experimental Farm will mark a distinct step in the advancement of our knowledge of this subject.

I have the honour to be,

Your obedient servant,

WM. SAUNDERS,
Director of Experimental Farms.

OTTAWA, April 6, 1908.



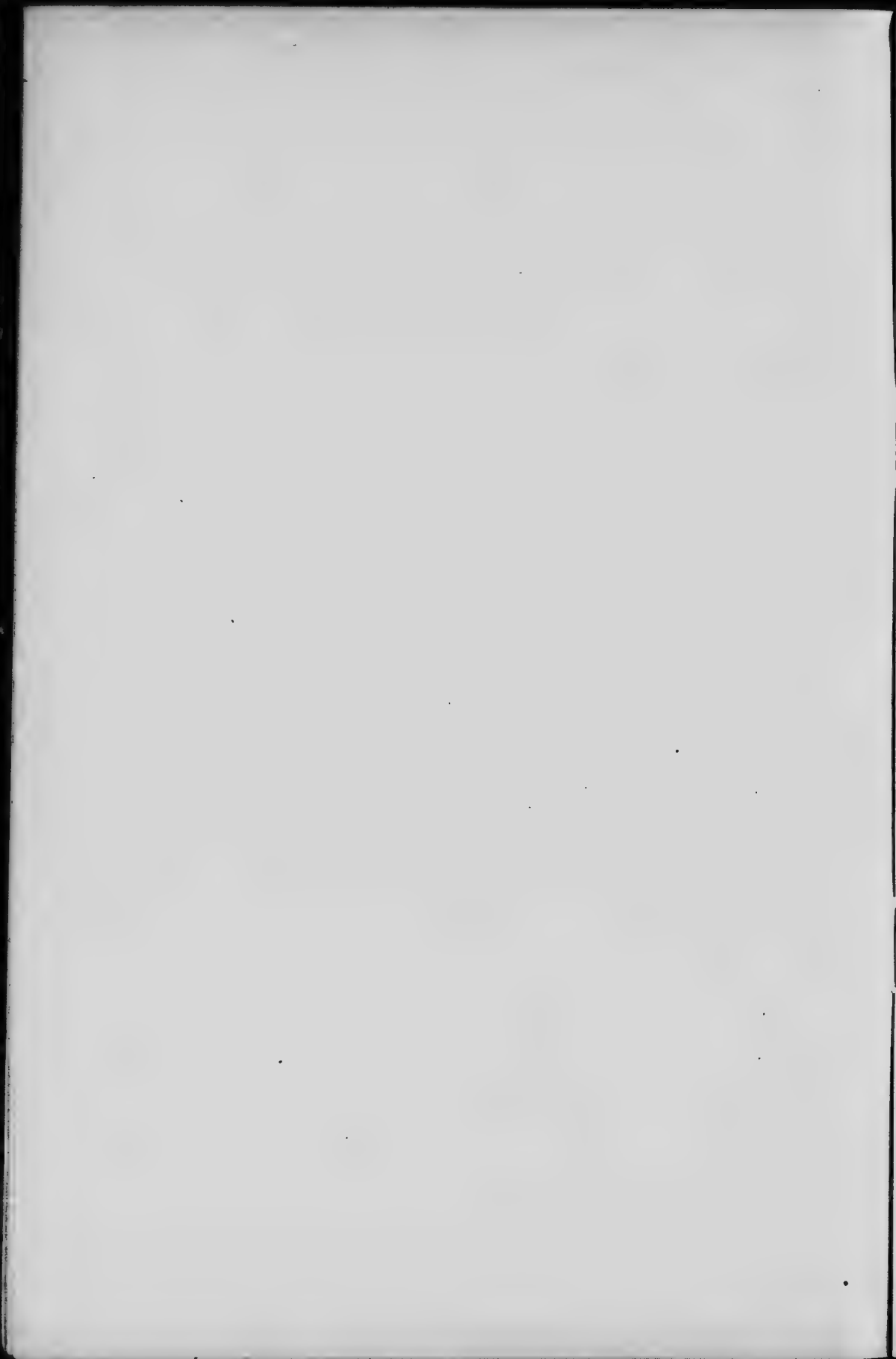
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PART I

THE MILLING AND BAKING QUALITIES OF THE GRADES OF WHEAT IN THE MANITOBA INSPECTION DIVISION, CROP OF 1907.

By CHAS. E. SAUNDERS, B.A., Ph. D., *Cerealist*.

Owing to the unusual character of the summer of 1907, it seemed desirable to study the various grades of wheat somewhat after the plan adopted when dealing with the crop of 1904 (Bulletin No. 50) in order to determine, as far as possible, whether the wheat in the higher grades was in any way affected by the coolness of the season, and also to ascertain the relative values of the lower grades (Nos. 4, 5 and 6), which were established by the Western Grain Standards Board to provide for the proper classification of such lots of wheat as showed more or less striking defects due to frost, water, premature cutting, &c.

When dealing with the crop of 1904, the work was undertaken rather late in the winter and the samples used for study were forwarded to us from Winnipeg by Mr. David Horn, Chief Inspector of Grain, from the large lots under his charge, representing the *averages* of the grades. In the present investigation it was thought desirable to begin the work much earlier. We, therefore, made use of a set of "official samples," dated October, 1907, and received at Ottawa in sealed bags on November 13th, from the Secretary of the Western Grain Standards Board.

In answer to an inquiry in regard to the exact significance of these samples, Mr. David Horn wrote "The type samples represent the different grades as they can leave Fort William. They represent the minimum in quality and the maximum in impurities. Millers would of course clean and purify to meet the needs of their trade."

Though these were composite samples, and thus strictly representative, it must be noted that they were somewhat lower in quality than those used from the crop of 1904; because, of course, the *average* of each grade is necessarily higher than the *legal minimum*. It is fair to suppose, therefore, that the average quality of each grade this season would be about midway between the figures here obtained and those of the grade next higher.

The samples received were as follows:—

- No. 1 Manitoba Hard.
- No. 1 Manitoba Northern.
- No. 2 Manitoba Northern.
- No. 3 Manitoba Northern.
- Commercial Grade, No. 4.
- Commercial Grade, No. 5.
- Commercial Grade, No. 6.
- Commercial Grade, Feed.

The grade last mentioned is sometimes referred to as No. 1 Feed.

DESCRIPTIONS OF THE SAMPLES AS RECEIVED.

The samples of the different grades were received in excellent condition. The impurities present in the wheat consisted of wild oats, oats, barley, flax, smut balls, weed seeds, chaff, bits of straw, &c. Every grade had some "smut-balls," but there were not many

in any of the samples. The higher grades had so very few that they could fairly be said to be, in a commercial sense (for milling), quite free from smut. For seed purposes it would, perhaps, be unsafe to use even No. 1 Hard without some treatment to destroy the smut spores.

No. 1 Manitoba Hard.—This sample consisted almost altogether of hard red, plump kernels, very few soft kernels being present. Careful counting showed about three immature, shrunken kernels in every hundred. Practically free from "frosted" kernels, that is, kernels with pale, roughened skin, due to the action of frost or water, or both. No appreciable odour of smut.

No. 1 Manitoba Northern.—Distinguished from No. 1 Hard chiefly by the larger proportion of starchy kernels present, and of kernels which are somewhat shrivelled. Has about ten shrunken kernels in every hundred. Practically free from kernels showing action of water or frost. No appreciable odour of smut.

No. 2 Manitoba Northern.—Very much like No. 1 Northern, but with a slightly larger proportion of defective kernels. Contains about twelve defective kernels in every hundred, about eleven of these being shrunken and one plump, but with a rough skin due to the action of water or frost. No appreciable odour of smut.

No. 3 Manitoba Northern.—Contains about twenty-three defective kernels in every hundred, about twenty being shrunken (some showing also the effect of water or frost), and three being plump, but with the skin affected by water or frost. Very slight odour of smut.

Commercial Grade No. 4.—Contains about thirty defective kernels in every hundred. Of these about 27 are shrunken (some showing also the effect of water or frost), and three are fairly plump, but affected by water or frost. Slight odour of smut.

Commercial Grade No. 5.—Contains about fifty-six defective kernels in every hundred. Of these about forty are shrunken (many showing also the effect of water or frost), and sixteen are fairly plump, but affected by water or frost. Slight odour of smut.

Commercial Grade No. 6.—Contains about sixty-five defective kernels in every hundred. Of these about fifty are shrunken (most of them showing also the effect of water or frost), and fifteen are fairly plump, but affected by water or frost. Distinct odour of smut.

Commercial Grade, Feed.—Contains about eighty-eight defective kernels in every hundred. Of these about sixty-three are shrunken (most of them showing also the effect of water or frost), and twenty-five are fairly plump, but affected by water or frost. Distinct odour of smut.

CLEANING AND MILLING OF THE SAMPLES.

Before milling, the wheat was cleaned by sifting and hand picking until nearly free from oats, barley, weed seeds, &c., the cleaning being carried to about the same extent as in ordinary milling practice. In addition to kernels of other grains, weed seeds, &c., the material removed contained a considerable proportion of very small, shrunken wheat kernels and fragments of kernels.

The method of milling was essentially the same as that used in previous investigations, and fully described in Bulletins 50 and 57. The effort was made to put into the "straight grade" flour all the material which could fairly be said to be fit for bread-making, and at the same time to keep the colour of the flour from the lower grades as close as practicable to the standard of the upper grades. The low grade flour, shorts and bran were not determined separately. The yields of flour are expressed as percentages of the total products obtained. There was a loss in milling of about two per cent of the material ground.

It should be mentioned that in an experimental flour mill working with small quantities of wheat, the yield of flour must always be sacrificed, to a certain extent, if a fair standard of colour is to be maintained. The yields published are intended, therefore, to show the relative values of the grades for the production of good flour, and do not show the total quantity of such flour obtainable from each grade in large mills.

The following table shows the weight of a measured bushel of each sample as received, the loss in cleaning, and the weight of a measured bushel after cleaning; also the yield of break flour and of straight grade flour. It seemed unnecessary to make any flour from Feed wheat.

Milling Number.	Grade.	Weight per bushel as received.	Loss in cleaning.	Weight per bushel after cleaning.	Break flour.	Straight Grade flour.
		Lbs.	Per cent.	Lbs.	Per cent.	Per cent.
160	No. 1 Manitoba Hard.	62½	.9	62½	9½	66
162	No. 1 Manitoba Northern....	61½	2.3	61½	10	62½
163	No. 2 Manitoba Northern....	61	2.8	61½	10	62
165	No. 3 Manitoba Northern....	59½	3.7	60	9	59½
166	Commercial Grade, No. 4....	58	4.5	58½	8	56
168	Commercial Grade, No. 5....	58	3.2	58½	7½	56
169	Commercial Grade, No. 6....	56	3.5	57½	6	50½
.....	Commercial Grade, Feed.....	54				

COLOUR OF FLOUR.

In the dry condition the straight grade flours from the three upper grades appeared identical in colour. No. 3 Northern, No. 4 and No. 5, gave flour of almost uniform colour, but somewhat less bright than that from the higher grades. The flour from No. 6 was slightly duller than any of the others.

After being moistened and dried all the flours were, of course, darker in colour, but fell naturally into the same three groups as before.

Since the commercial value of flour is so much affected by colour (quite apart from the question of baking strength,) it is evident that the flour from No. 3 Northern, No. 4 and No. 5 would be of somewhat less value per pound than that from the upper grades; while the flour obtained from No. 6 would bring a still lower price.

BAKING TESTS.

The milling tests of the grades were completed on December 5th, 1907. The baking tests were postponed until early in January, 1908, so that the samples of flour might come to a fairly uniform character in regard to moisture content, and be baked under the usual conditions which are maintained in this laboratory. Furthermore, although very little is known in regard to the improvement of wheat and flour by keeping, it seemed probable that unfair and misleading results might be obtained if the baking tests were made before either the wheat or flour had been allowed any reasonable chance to improve with age.

Full details in regard to the method of baking, and the manner in which the figures for baking strength and bread value are computed have been given in Bulletin No. 57 of the Experimental Farm Series. They need not, therefore, be repeated here. Two slight changes require to be mentioned, however.

As it is not always possible to keep the samples of flour together for a sufficiently long period to bring them to about the same moisture content, and as even in mid-winter the weather of one season is sometimes different from another, it has seemed necessary to adopt some standard for the amount of moisture normally present in flour at the time the tests are usually made (mid-winter) in this laboratory. Eight per cent has been taken as the standard for moisture. The variations from that figure are usually negligible if the flour has been kept for a few weeks under our normal mid-winter conditions. Where particular accuracy is required, or where the moisture content is considerably greater or less than eight per cent, the figures actually obtained in the baking tests are recalculated to that basis.

The method of determining volume of loaf has been improved by the use of rape seed, instead of flax, and by direct measurement of the seed instead of calculating its volume from its weight. It was found that the weight of a given volume of flax seed varied according to age, moisture in the atmosphere, &c. A fairly constant error due to this method of determining volume was present in the figures published in Bulletin 57, though the results of each season were quite sufficiently accurate among themselves. In order to prevent the correction in the determinations of volume (which are now somewhat lower than before) from shifting downward the whole scale of marks for baking strength, it has been found necessary to subtract 670 instead of 700 from the large total of marks obtained. (See Bulletin 57, page 18.) In this way the figures for baking strength in this and in future researches will be kept comparable with those already published.

The slight changes just mentioned will account for the discrepancy between some of the figures in the following tables and those published in the preliminary report of this work, which was given to the press as soon as the tests were completed.

In regard to volume of loaf, it should be noted that owing to the small size of the loaves made, their proportion of crust is relatively large. It follows, therefore, that the actual lightness of the interior is greater in these small loaves than in larger loaves which give the same figures for volume (from each 100 grammes of flour.)

BAKING TESTS, JANUARY, 1906.

Milling Number.	Grade.	Water added to 100 grammes of flour.	Water retained by 100 grammes of flour.	Volume of loaf from 100 grammes of flour.	Height of loaf divided by diameter.	Form of Crust.	Texture.	Inside Colour.	Time of fermentation.
									H. M.
160	No. 1 Hard.....	65	41.5	492	.65	87	97	96	3 20
162	No. 1 Northern.....	66.5	44.5	443	.61	94	95	96	3 14
163	No. 2 Northern.....	66	44	438	.62	96	95	96	3 8
165	No. 3 Northern.....	67	46	383	.60	96	86	88	3 0
166	No. 4.....	68	46.5	397	.59	94	86	83	2 56
168	No. 5.....	68.5	47.5	366	.58	93	84	80	3 10
169	No. 6.....	69	47	363	.59	98	81	70	3 24

BAKING STRENGTH AND BREAD VALUE.

Milling Number.	Grade.	Baking strength.	Bread value.	Remarks
160	No. 1 Hard.....	95	96	Lowest in the series in water adsorption but highest in volume.
162	No. 1 Northern.....	91	92	Almost identical with No. 2 Northern.
163	No. 2 Northern.....	91	92	Almost identical with No. 1 Northern.
165	No. 3 Northern.....	83	84	Much lower in volume than the highest grades, also of poorer colour.
166	No. 4.....	84	84	Very slightly superior to No. 3 Northern in some respects, but inferior in colour.
168	No. 5.....	80	80	High in water adsorption but dough is hard to work and quite sticky.
169	No. 6.....	80	78	Very much like No. 5 except in colour, which is much inferior.

COMMENTS ON RESULTS.

An examination of the tables shows that the flours fall naturally into three groups.

The first group consists of the three upper grades (No. 1 Hard, Nos. 1 and 2 Northern) which yield strong flour of good colour and show a baking strength of over 90 points. The fact that No. 1 Hard absorbed less water than either of the other grades in the group is difficult to explain. The much smaller weight of the loaf produced is partly due to the fact that larger loaves dry out to a greater extent than smaller loaves (made from the same weight of flour) when baked in the same way.

The second group contains the two grades No. 3 Northern and No. 4. The flours obtained from these grades are of about equal value, but the yield was three and a half per cent greater from No. 3 Northern than from No. 4. They both give flour distinctly inferior to the upper grades in strength and colour; and in spite of their high water absorption they cannot be ranked as strictly first-class from the standpoint of the commercial baker. No doubt a certain amount of high grade flour could be obtained from No. 3 Northern but a good yield of such flour appeared impossible at the time when these tests were made. For the production of strong flour, wheat usually improves with age when stored under good conditions and it is therefore quite possible that the two grades here considered may show striking improvement in colour and strength of flour in the course of a few months from the date of the conclusion of these tests (January 17th). At the time this work was done these two grades yielded good household flour which should be satisfactory to anyone not requiring a product of high strength. While such flour would not command the highest price for mixing purposes it could probably be used to good advantage if blended with the product from some other types of wheat of quite different character.

The third group consists of the grades No. 5 and No. 6. The official standard samples of these grades as tested cannot be recommended for milling purposes, though it is probable that good flour can be made from some exceptional lots of No. 5, if the low grade has been given on account of the shrivelled skin of the wheat and not because the kernels were lacking in plumpness.

From the tests of these lower grades, and from similar tests of some other samples of "frosted" wheat which were studied this season, it appears that one should not expect to obtain good flour from badly "frosted" wheat weighing less than 60 lbs. to the measured bushel.

CROP OF 1904 COMPARED WITH CROP OF 1907.

The crop of 1904 (see Bulletin No. 50) was of an unusual character owing to the prevalence of rust. It was therefore to be expected that the grades of the past season would show some points of difference from those of 1904. The flours from the grades of 1904 showed a lower water absorption and a lower protein content than those of 1907 (see Part II, page 14) but gave bread of larger volume, especially in the lower grades. These observations perhaps justify the conclusion that wheat which is lacking in plumpness on account of the action of rust will produce better flour than wheat, of about the same degree of plumpness, which has been injured by frost.

PART II.

A CHEMICAL STUDY OF THE GRAIN AND FLOUR OF THE GRADES
OF WHEAT—1907.

BY

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In this work the general plan of analysis followed has been that adopted at the present day in the more complete examination of wheat and flour and already outlined in Bulletin No. 50, of the Experimental Farm Series. This, in addition to furnishing data of an exhaustive character regarding the composition of the grain and flour, allows the more or less direct comparison of the data with the results obtained on similar samples from the grades of 1904 and given in the aforesaid bulletin.

In Bulletin No. 57, "Quality in Wheat" (Experimental Farm Series), in speaking of the components of flour which influence strength, the writer referred to recent work on this subject by Mr. T. B. Wood of the University of Cambridge. This investigator, accepting "strength" as applied to flour to be the capacity of forming "large and well-piled" loaves, puts forward the view that strength is determined by two separate factors—the one influencing the size or volume of the loaf, the other its shape, and presents certain data to support that view. We have been enabled to do some investigatory work in this new and interesting field and the results are presented and discussed in the chapter dealing with the flours of the grades.

FROZEN OR "FROSTED" WHEAT.

Before considering the data of the present research, it is desirable to say a word or two respecting the wheat crop of which the various grades are representatives. The season of 1907 was in many districts in the Canadian North-West extremely and exceptionally unfavourable to the production of first class grain. Heavy or continuous rains with low temperatures prevailed over large areas during a considerable part of the growing season, retarding the development of the wheat plant and the maturing of its seed. Unfortunately there followed in the early autumn injurious frosts, finding much of the grain still in the "dough" stage. The result of these conditions has been that large quantities of frozen or "frosted" wheat have been harvested, a considerable proportion of which was too immature and too badly injured to be useful for flour making, though, as our analyses and practical trials show, it has a distinct and indeed high feeding value for various kinds of stock.

The terms "frozen" and "frosted" as applied to wheat are employed indiscriminately, or apparently so, the extent of the injury being usually denoted by an adjective, such as badly or slightly. It does not seem desirable to use either term without some qualifying adjective, as the effect of frost may from the miller's standpoint, render a wheat valueless or on the other hand leave it practically unscathed. A wheat then may be seriously or only slightly injured, depending, it would seem, on one or both of two factors. The chief one undoubtedly is the stage of the growth of the wheat when caught by the frost, the less mature grain suffering most; but we must also suppose that the degree of frost to which the ripening wheat is subjected has its effect. Thus we find that when frost, though comparatively slight, occurs while the grain is still in the early "dough" stage, development is arrested and there results a small, shrunken, badly discoloured grain; on the other hand a more severe frost delayed until the berry is almost ripe may give a fairly plump grain of good colour, the indication of frost being noticeable only in its shrivelled skin. The effect of water on the skin of the grain is apparently very similar to that of frost.

The injury from frost or wet to the wheats under consideration is discussed in Part I (page 8), it will therefore be only necessary to say here that a casual examination of the grades shows an almost negligible proportion of kernels affected by frost or water in No. 3 Northern, and that the grades above this number appear to be free from such defective kernels. Grades below No. 3, and especially No. 6 and "Feed," show a large proportion of frosted and shrivelled grain.

PREPARATION OF THE SAMPLES.

In the case of the first four grades the samples as analysed were prepared by a slight cleaning, (see Part I, page 8) by which was removed the greater portion of such foreign and accidental matter (chiefly oat and barley kernels) as might be present. This cleaning took out from .9 to 3.7 per cent and left the wheat suitable for general milling purposes.

To ascertain the extent to which the foreign matter present might influence the composition, grades Nos. 4, 5 and 6 were analysed as received and also after a preparatory cleaning as already outlined. These lower grades, naturally, contain a larger proportion of foreign matter than any of the first four members of the series. "Feed" was analysed only as received.

COMPOSITION OF THE WHEATS.

Moisture.—The percentages of moisture are for the most part markedly higher than those which have been usually obtained in the analysis of North-Western wheats. This does not necessarily indicate, in the opinion of the writer, an exceptionally moist grain, due to immaturity or other causes; it is perhaps to be explained by the fact that previous analyses have for the most part been made later in the season and after the grain had lost moisture from exposure for a prolonged period to the excessively dry air of winter.

It is also to be remarked that it has been customary in previous work on wheat to determine the percentage of moisture on the finely ground grain as prepared for analysis. The results given in this bulletin are those obtained on the coarsely ground wheat. This, as experiment has shown, will give slightly higher percentages than if the determination is made on the fine powder, there being a loss of moisture, frequently amounting to between one and two per cent, in the final reduction in the mill. This fact led us to make separate grindings for the moisture determinations, and necessitated also moisture estimations on the finely ground wheat (as prepared for analysis) for the recalculation of the remainder of the analytical data to the basis of the original water content. The additional work which this involved is, we think, compensated for by the greater accuracy obtained.

ANALYSES OF WHEATS.

Designation of Sample.	Weight of 100 kernels	Moisture.	Crude Protein. (N $\times$ 6.25)	Fat.	Carbo-hydrates.	Fibre.	Ash.
	Grammes.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
No. 1 Manitoba Hard*.....	2.895	13.02	13.66	1.06	67.60	2.31	1.61
No. 1 Manitoba Northern*.....	2.609	13.35	13.45	2.12	67.04	2.31	1.73
No. 2 Manitoba Northern*.....	2.300	12.99	13.41	2.13	67.37	2.37	1.73
No. 3 Manitoba Northern*.....	2.760	13.42	14.09	2.06	66.46	2.31	1.66
Commercial Grade No. 4*.....	2.470	12.02	13.96	2.32	67.56	2.43	1.73
Commercial Grade No. 4†.....		13.22	13.46	2.39	66.41	2.74	1.73
Commercial Grade No. 5*.....	2.619	12.33	13.81	2.33	67.42	2.40	1.71
Commercial Grade No. 5†.....		10.96	14.08	2.41	68.09	2.65	1.79
Commercial Grade No. 6*.....	2.427	12.06	14.30	2.45	66.73	2.63	1.75
Commercial Grade No. 6†.....		12.62	13.84	2.46	66.54	2.74	1.80
Commercial Grade No. 7†.....	2.371	13.45	12.20	2.44	66.84	3.10	1.97

* As cleaned for milling

† As received.

Crude Protein.—In the calculation of this constituent, the most important in the wheat grain, the factor 6.25 for multiplying the total nitrogen in the grain has been employed. Recent research has shown that the factor 5.7 gives results nearer the truth, but as it has not yet come into general use, the older factor has been retained in the wheat analysis in order to make our data readily comparable with those already published on wheat from American sources. In the flour analysis the factor 5.7 has been used.

Viewed from the standpoint of protein content, the whole series ranks exceptionally high, and especially is this true considering the comparatively large percentages of moisture present. As the results stand the data show that the wheats of the grades of 1907 contain from 1 p.c. to 2 p.c. more protein than those of 1904 (*see* Bulletin No. 50, Experimental Farm Series); if the results of both seasons were calculated to the same moisture content the difference would be still greater. It seems more than probable that this high protein content may, in part at least, be attributable to the peculiarities of the last season, to which we have already referred. Though no doubt the wheat in many sections, as is usual, reached a full ripeness there is ample evidence that over large areas development was so checked by low temperatures and wet weather that much wheat made but little progress for weeks together and this appears to have been the case especially when the grain was in the dough stage. This wheat was harvested in a more or less immature condition and subsequent to cutting there was found to be very little filling out of the grain. This view of a high crude protein content as resulting from a certain degree of immaturity is quite consonant with the conclusions to be drawn from our studies on frozen wheats—which are necessarily immature wheats. Such are invariably high in crude protein (total nitrogen $\times 6.25$), though as recent analyses have shown, a small part of these nitrogenous compounds are of a non-albuminoid character. The discussion of the wheats of the various grades from the standpoint of the effect of frost will be taken up in a succeeding paragraph.

Among the grades as used for milling purposes no very marked differences in protein content occur. The figures for the first three members of the series are practically within the limit of experimental error. "Feed" has a somewhat lower percentage of protein than the grades above it, due no doubt to the larger proportion of refuse it contains. Excepting this number the maximum difference is found to be .89 per cent.

We have already alluded to the investigations made, some years ago, in which the writer showed that frosted wheat was characterized by a higher protein content than similar wheat that had normally ripened, in other words, that frosted grain is in a measure immature grain and accordingly more nitrogenous than if the season had permitted the grain to become plump through the later deposition of starch. It may be asked, therefore, how far the present data support this view, since as we have already noticed, signs of frost (or wet?) are apparent in No. 3 Northern and increase somewhat from this number to the close of the list.

The evidence is as follows, from the cleaned samples.

Crude Protein.		Crude Protein.	
	per cent.		per cent.
No. 1 Manitoba Hard.....	13.68	No. 3 Northern.....	14.09
No. 1 Northern.....	13.45	No. 4 Commercial Grade.....	13.96
No. 2 Northern.....	13.41	No. 5 Commercial Grade.....	13.81
		No. 6 Commercial Grade.....	14.30
Average protein-content in frost-free sam- ples.....	13.51	Average protein-content in samples show- ing frost.....	14.04

Though perhaps not furnishing evidence of a very pronounced character the writer thinks the data strengthen the deduction reached from previous research respecting the higher percentages of protein in frosted and immature grain.

"Cleaning" as a rule raised the protein content, the exception being in the case of No. 5. The amount and the nature of the foreign material taken out, as for instance seeds or fragments of straw, would naturally determine the extent and direction of the change.

Feeding value of lower grades.—So far as can be determined by chemical analysis, we have in the lower grades wheat that should prove very valuable for feeding purposes, wheat characterized by what might be termed an exceptionally large percentage of that most valuable constituent protein.* There seems every reason to premise that, fed judiciously, frosted wheat will equal normally ripened wheat. Of course the proportion of foreign matter—offal—present will correspondingly reduce the feeding value and this fact must not be lost sight of when "feed" wheat is under consideration.

Fat.—No great differences are to be observed in the fat data, but it is interesting to note that the percentages of this constituent in the lower grades are somewhat higher than those of the first four members of the series. This perhaps may be construed as indicating more fat in the immature (frosted) grain than in that normally ripened. In 1904 we similarly found a higher fat content in the "frosted" and "feed" members of the series. This is a matter that will receive our further attention during the present season.

We have again to note, taking the series as a whole, that the percentage of fat is considerably higher in these wheats than in winter varieties—a fact of some importance from the nutritive standpoint.

Fibre and Ash.—There is nothing abnormal to be remarked respecting the data for fibre and ash, though the constantly increasing percentage of fibre as we proceed from the highest to the lowest grades, following the proportion of shrunken and shrivelled kernels, is to be noted. As might be expected the percentages of fibre and ash are invariably somewhat higher in the samples "as received" than in the wheats "as cleaned for milling". "Feed", owing to its large proportion of foreign matter presents the largest percentages of these constituents.

Weight of the Kernel.—Previous investigations with wheat of the same type have shown that the weight of the kernel bears a more or less definite relationship to the weight per bushel and the percentage of straight grade flour that may be obtained—the heavier the kernel the greater the weight per bushel and the larger the percentage of first grade flour. The results from the 1907 wheats do not show this relationship throughout the series. The data may be tabulated as follows:—

Designation of Sample.	Weight of 100 kernels.	Weight per bushel (after cleaning).	Yield of straight grade flour. (See Part I.)
	Grammes.	Lbs.	Lbs.
No. 1 Hard.....	2 895	62½	65
No. 1 Northern.....	2 699	61½	62½
No. 2 Northern.....	2 309	61½	62
No. 3 Northern.....	2 760	60	59½
Commercial Grade No. 4.....	2 470	58½	56
Commercial Grade No. 5.....	2 619	58½	56
Commercial Grade No. 6.....	2 427	57½	50½

The writer is inclined to think that the presence of "frosted" grain in the lower members of the series is the disturbing influence this year and furnishes in part, at least, the explanation for the lack of agreement between the weight of the kernel and yield of flour. The yield of straight flour is determined from the standpoint of colour, and frosted wheat furnishes a flour more or less dark or "off" colour, according to the extent of injury. Wheat

*A series of analyses recently made with the view of determining more correctly the nature of the nitrogenous compounds in frozen and immature wheat reveals the fact that a small proportion of the so called crude protein consists of non-albuminoid substances which, as is well known have a somewhat lower feeding value than true proteins.

but slightly touched with frost when almost ripe will yield a larger amount of good colour (straight) flour than one seriously frozen while still immature. It is evident, therefore, if the grades have been fixed chiefly by the degree or extent of frost showing (which will be relative to the amount of "straight" flour) rather than by other characteristics e. g. plumpness, size and weight, the direct relationship we have referred to as observed in former seasons, will in this series be upset and irregular.

COMPOSITION OF THE FLOURS.

Straight flours were prepared by the Cerealists from all the foregoing grades save "Feed" in the experimental roller mill. These furnished the samples used in the determination of the breadmaking values already given in Part I., and for the chemical work now about to be detailed, thus allowing the correlation of the two classes of data, as far as such may be practicable.

The chemical estimations include moisture, protein, fat, fibre, ash, wet and dry gluten, the proportion of protein in the form of gliadin and the nitrogen, ash and certain other constituents in the water-soluble extract of the flours.

ANALYSES OF FLOUR.

Designation of Sample.	Moisture.	Protein or albumin- oids (N $\times$ 5.7).	Fat.	Carbo- hydrates.	Fibre.	Ash.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
No. 1 Hard.....	9.60	12.05	1.28	76.34	.17	.57
No. 1 Northern.....	9.18	12.18	1.36	76.47	.20	.64
No. 2 Northern.....	9.53	12.43	1.26	75.03	.21	.66
No. 3 Northern.....	9.32	11.97	1.48	76.28	.19	.66
Commercial Grade No. 4.....	9.37	13.60	1.47	75.78	.18	.66
Commercial Grade No. 5.....	9.45	12.43	1.37	75.86	.19	.70
Commercial Grade No. 6.....	9.41	12.03	1.47	76.11	.23	.70

Moisture.—The proportion of moisture in a flour is largely determined by the atmospheric conditions under which it is stored. It must not be supposed, therefore, that the percentages here recorded are those which would be found in flours from these grades upon the market; in such the probability is that the moistures would be considerably higher due to conditions of storage less favorable to the drying out of the flours. Flours in commerce usually contain from 11 p.c. to 13 p.c. moisture, varying to a certain degree with the season of the year, the air being more humid, and consequently the flour somewhat more moist, in the summer.

A noticeable feature is the uniformity in moisture content throughout the series, undoubtedly the result of previously submitting all the samples for a period of several weeks to the same atmospheric conditions. This uniformity allows the comparison of the analytical data generally without further calculation.

Protein or Albuminoids.—It has already been remarked that the wheats of these grades were characterized by a higher protein content than those of 1904. The same is true as regards the flours. In 1904 the average was 11.06, in the present series 12.24 per cent. Possibly this increase in protein content does not indicate any marked increase in quality or strength, for it has not been found, invariably, that the bread making value of a flour is directly and simply dependent on the percentage of protein present: indeed as already hinted, it may be an indication of slight immaturity owing to the abnormal and backward season last year in many parts of the Northwest, and in such case we could not regard it as denoting any superiority, save perhaps from the nutritive standpoint.

No differentiation of the flours can be attempted from the standpoint of their protein content, by reason of the fact that the percentages of this constituent throughout the series

are extremely close; there is no marked departure from the average (12.24) obtained from the seven samples. It is commonly supposed that No. 1 Hard obtains this rank by virtue of being able to produce a flour with a larger percentage of protein and gluten, but neither the results from the 1904 grades (Bulletin 50, Exp. Farm Series) nor from the present series lend any support to that view.

Fat.—The percentages of this constituent are very similar to those obtained from the flours of the grades of 1904 (Bulletin 50, Exp. Farm Series), and furnish additional evidence of the richness in this nutritive element of flours from the Northwest wheats. The average percentage of fat, as obtained by the Division of Chemistry, Department of Agriculture, Washington, D.C., from the analysis of 40 samples of "patent" flour is given as 1.02; the average of the present results is 1.38 per cent.

GLIALIN, GLIADIN RATIO AND WET AND DRY GLUTEN.

Designation of Sample.	Gliadin.	Proportion of Albuminoids in the form of Gliadin.	GLUTEN.			
			Wet.	Dry.	Ratio of dry to wet.	Physical Character.
	per cent.	per cent.	per cent.	per cent.		
No. 1 Hard.....	5.43	45.1	41.73	14.94	2.80	Good.
" 1 North.....	5.20	43.4	41.13	14.65	2.81	"
" 2 ".....	5.57	44.5	42.18	15.27	2.80	"
" 3 ".....	5.03	42.0	39.54	14.04	2.81	"
Commercial Grade No. 4.....	5.05	40.2	41.27	14.63	2.82	"
" " " 5.....	4.91	39.5	39.38	13.43	2.93	"
" " " 6.....	4.88	40.6	38.33	12.89	2.70	Fair, s. dark.

Gliadin and Gliadin Ratio.—The nature and value of these determinations have been fully considered by us in several recent publications and more particularly in Bulletin No. 57 on the "Quality of Wheat" October, 1907. It will not be necessary, therefore, here to enter upon any detailed discussion as to the bearing of these data on the bread making value of a flour.

It may suffice to say that the view that a good, strong flour should contain from 55 per cent to 65 per cent of its protein in the form of gliadin has not received any support from our investigations. Neither have we found the later theory, that strength is relative to the amount of gliadin present, invariably holds good, though there is some evidence in its favor from our work. It will be observed that the results both as to gliadin and gliadin ratio are slightly higher for the first three grades than for the last three, though no definite or regular differences are to be noticed as we ascend or descend the scale. Is this falling off in gliadin due to immaturity or the effect of frost? Further work is necessary to show how far this may be the case. Compared with the flours of the 1904 grades, the percentages of gliadin in the present series are higher, the average for the former being 4.76 per cent, for the 1907 flours 5.17 per cent.

Wet and Dry Gluten.—These results follow fairly closely the percentages of protein and are therefore considerably higher than those obtained from the 1904 flour. The averages are for 1904, wet gluten 36.15 per cent, dry gluten 12.61 per cent; for 1907 wet gluten 40.50 per cent, dry gluten 14.40 per cent. It is interesting to observe, however, that the ratio of wet to dry gluten is practically the same for both series viz. 2.86 and 2.81.

The quality of the gluten with the exception of that from No. 6, which was slightly dark, was excellent throughout the series, being firm, elastic and of good colour.

THE WATER-SOLUBLE CONSTITUENTS OF THE FLOURS.

We have already briefly referred (page 12) to the views recently promulgated by Mr. T. B. Wood, of the University of Cambridge regarding the factors that determine strength in flour. As these views were discussed in our Bulletin No. 57, "Quality in Wheat," pages 38, 39, it will not be necessary here to do more than repeat the propositions in very concise form. Mr. Wood concludes from his work that the rise of the loaf and the shape of the loaf are determined each by its own separate and distinct factor; that the former is determined by "the amount of sugar contained in the flour together with that formed in the dough by diastatic action," while the latter is dependent upon certain physical properties of the gluten which are in turn consequent upon the presence in varying proportions of certain small quantities of mineral salts, in other words "that strength is associated with a high ratio of proteid to salts and weakness with a low ratio" Mr. Wood says: "It is suggested that the variation of this ratio may be the explanation of the different physical behaviour of the gluten of strong and weak flours, and that this is the factor which determines that component of strength which governs the shape of the loaf and its power of retaining gas." It is upon this latter problem that we have been more particularly engaged in our examination of these flours, and our results may now be presented.

Following the plan outlined by Mr. Wood, 100 grammes of flour were shaken for three hours with 1000 c.c. of distilled water. After standing some time to settle, the supernatant extract was filtered, the operation being hastened by a suction pump, and the filtrate tested to insure the absence of starch. Upon this filtrate the following determinations were made in duplicate; total solids, ash, alkali as potash, phosphoric acid as P_2O_5 and nitrogen. The results are tabulated below:

FLOURS: SOLIDS, ASH, NITROGEN, &c., IN AQUEOUS EXTRACT.

Designation of Sample.	PERCENTAGES OF SOLUBLE CONSTITUENTS OF FLOURS.						BAKER'S MARKS.
	Total Solids.	Ash.	Nitrogen.	Alkali as K_2O	Phosphoric acid as P_2O_5	Nitrogen and Ash-free extract.	
No. 1 Manitoba Hard.....	8.83	.34	.322	.181	.130	3.68	492
" 1 " Northern.....	6.74	.40	.333	.108	.135	4.37	500
" 2 " ".....	6.54	.33	.340	.184	.117	4.32	435
" 3 " ".....	8.31	.44	.335	.184	.181	8.00	383
Commercial Grade No. 4.....	10.99	.43	.355	.184	.133	8.54	397
" " " 5.....	10.89	.40	.350	.190	.171	8.05	366
" " " 6.....	11.01	.53	.362	.201	.145	9.16	363

An increase, though not a regular one, is to be observed in these soluble constituents as we proceed from the first to the last of the series. This increase is most marked in the case of the total solids and nitrogen and ash-free extract. This seems to show that the larger amount of this increase in the flours of the lower grades is non-nitrogenous organic matter. If we suppose, as does Mr. Wood, this nitrogen and ash-free extract to be of the nature of a sugar in so far as gas production is concerned, then according to the theory advanced the volume of the loaf produced should increase pro rata. Such, however, is not the case but rather the reverse, the volume of loaf according to the baker's results, decreasing almost step by step with the grades of the series. This question of the relationship of volume to composition will again be referred to in presenting the data from the sugar determinations; at the moment it will be well to further study the foregoing data with a view of ascertaining

how far Mr. Wood's hypothesis, that shape of loaf is determined by the ratio to proteid of salts, is supported by the results from these flours.

The ratios given in the sub-joined table have been calculated from the percentages of nitrogen and soluble constituents of the flours, and represent the proportion to total nitrogen of soluble ash, alkali (as potash) and phosphoric acid (as P_2O_5).

FLOURS: RATIO TO TOTAL NITROGEN OF SOLUBLE CONSTITUENTS; SHAPE OF LOAF AND STRENGTH.

Designation of Sample.	Total Nitrogen.	RATIO TO TOTAL NITROGEN OF SOLUBLE			BAKER'S MARKS.	
		Ash.	Alkali.	Phosphoric acid.	Shape.	Baking Strength.
	%					
No. 1 Manitoba Hard.....	2.05	6.9	13.5	15.7	.65	86
No. 1 " Northern.....	2.14	5.3	12.8	15.3	.61	91
No. 2 " Northern.....	2.18	6.8	14.1	15.6	.63	91
No. 3 " Northern.....	2.10	4.8	11.4	16.0	.60	83
Commercial Grade No. 4.....	2.21	5.1	12.0	16.3	.60	84
" " No. 5.....	2.18	4.4	10.9	12.1	.55	80
" " No. 6.....	2.11	4.2	10.5	14.5	.60	80

From the baking results obtained by the Cerealist we learn that the figures for the shape of loaf (*i. e.* height divided by diameter) are higher for the first flours than for the last of the series, though the gradation throughout is not quite regular. If the theory is correct that the strength in so far as the shape of loaf is concerned, is controlled by the ratio to the proteid (or total nitrogen) of soluble ash constituents, the ratio increasing with the strength, then we ought to find some agreement between the tabulated ratios and the figures denoting shape. Is there such a relationship? Possibly, for we find higher ratios for the flours at the beginning than for those at the end of the series (as is the case with the results for shape of loaf) but it is evident that the two classes of data are not capable of direct correlation. The irregularities, if such they may be termed, may arise in part from experimental error, but one would scarcely feel justified from the present results in saying that there was a definite, constant relationship between this ratio and the shape of the loaf. The work so far is altogether too limited in extent to make any critical discussion of these apparent irregularities desirable or valuable, but there are indications in these results that have led us to conclude that this phase of the investigation is worthy of further study.

Sugars.—The sugars were determined both in aqueous and alcoholic extracts of the flours, according to the general plan of procedure outlined on page 43, Bulletin No. 57. The results show that water extracts from the flours much larger quantities of the substances reducing Fehling solution and recorded as sugars than does alcohol. That these substances are entirely made up of sugar is extremely doubtful, though they may be of such a nature as to more or less readily yield carbonic acid under the fermenting action of yeast. It is significant that the water-soluble sugars, and more particularly those directly reducing Fehling (recorded as maltose), are markedly higher for the lower members of the series, *i. e.*, in the flours from the wheats showing the effect of frost. This increase agrees very well with the total solids in the water soluble extract discussed in the preceding paragraph and which, it was observed, furnished much higher percentages for the flours from the lower and "Commercial" grades than for the first three or four of the series. This rise in water-soluble constituents (consisting of sugars or allied bodies) is most probably due to immaturity or the action of frost (the effect of frost being most marked on the lower grades of wheat) and is to be regarded, the writer thinks, as a sign of inferiority from the baker's

point of view. Be this as it may, there is no evidence here that with increase of sugars there is increase of volume in loaf, but rather the reverse. The baker's marks show a most decided falling off in the volume of loaf produced from the frosted wheat flours, as already noted. It would seem from this work that a further study of the water soluble carbohydrates in flours, and especially in flours from frosted and immature wheats, is worthy of attention. It is not improbable that such a research might furnish the explanation for the marked decrease in the volume of loaf.

SUGARS IN FLOUR EXTRACTS.

Designation of Sample.	IN AQUEOUS EXTRACT.			IN ALCOHOLIC EXTRACT. (70 % alcohol.)			Volume of loaf. (Baker's Marks.)
	Directly reducing, as Maltose.	After inversion, as Sucrose.	Total	Directly reducing, as Maltose.	After inversion, as Sucrose.	Total	
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	
No. 1 Hard.....	1.96	2.14	4.10	.13	.91	1.04	492
" 1 Northern.....	2.73	1.95	4.68	.20	.94	1.14	443
" 2 "	1.87	1.79	3.66	.12	.87	1.05	438
" 3 "	3.12	2.10	5.22	.26	1.21	1.47	383
" 4 Commercial Grade....	3.62	2.43	6.05	.05	1.34	1.39	397
" 5 " "	3.03	2.43	6.06	.06	1.42	1.48	346
" 6 " "	4.07	2.43	6.50	.06	1.36	1.42	363

Considering the sugars as extracted by 70 p.c. alcohol, we notice a falling off in the percentage of maltose (or sugars calculated as such) in flours from the frosted wheats as compared with the results from the sound flours, but the reverse to be the case with the sugars (or allied compounds) designated as sucrose. It will thus be seen that while there is a fair agreement or rather relationship between the results for sucrose, as obtained from the aqueous and alcoholic extracts respectively, the figures for the maltose (or directly reducing compounds) show no parallelism.

CONCLUSIONS FROM THE CHEMICAL INVESTIGATIONS.

I. The wheat of the past season, as represented by the grades of 1907, is characterized by a decidedly high protein-content. At first sight this might appear to give the wheat a superior rank for bread-making, since it has long been recognized that one of the most important factors in determining the value for bread making is the percentage of protein, i. e. gluten, present. Further consideration of the facts, however, warrant some hesitation before drawing such a conclusion. May not the high protein content be in some degree due to immaturity? If so, it would not necessarily, in the opinion of the writer, indicate increased "strength" as applied to bread-making, though it *might* mean a higher value from the nutritive standpoint. Frosted wheat as we have frequently shown is possessed of a higher percentage of protein than similar wheat that has come to a normal ripeness without frost: it is, in other words, immature wheat. It might be argued that this explanation would only apply in a consideration of the lower grades—those showing the effects of frost—but it is not improbable owing to the backward season last year that in some districts at least a considerable amount of wheat was cut in a "greener" condition than usual and that this failed to thoroughly ripen in the stock.

Attention has been called to the slightly higher protein content of the lower grades—a fact which rather strengthens the argument put forward in the preceding paragraph. The question of immaturity as affecting the "strength" of a flour has not received much

attention at the hands of the chemist or the baker, but it seems more than probable that it will be found one of great importance. Certainly the results presented in this bulletin point in that direction.

II. The relationship of the weight of kernel to the weight per bushel and the percentage of straight grade flour and which we have remarked in former work on the grades of wheat, is not very clearly seen in the 1907 samples. The reason for this is, we presume, the presence of the frosted kernels, especially in the lower grades. As explained, the proportion of straight flour obtained (as judged by colour) will be determined largely by the percentage of immature and frozen kernels, and from the milling results it would appear that this has been a guiding factor in the establishment of those grades showing frosted kernels.

III. The relationship between the protein, gliadin and dry gluten observed in previous work when examining normally ripened wheats is not here apparent. The absence of this relationship probably results from the effect of frost, so observable in the lower grades.

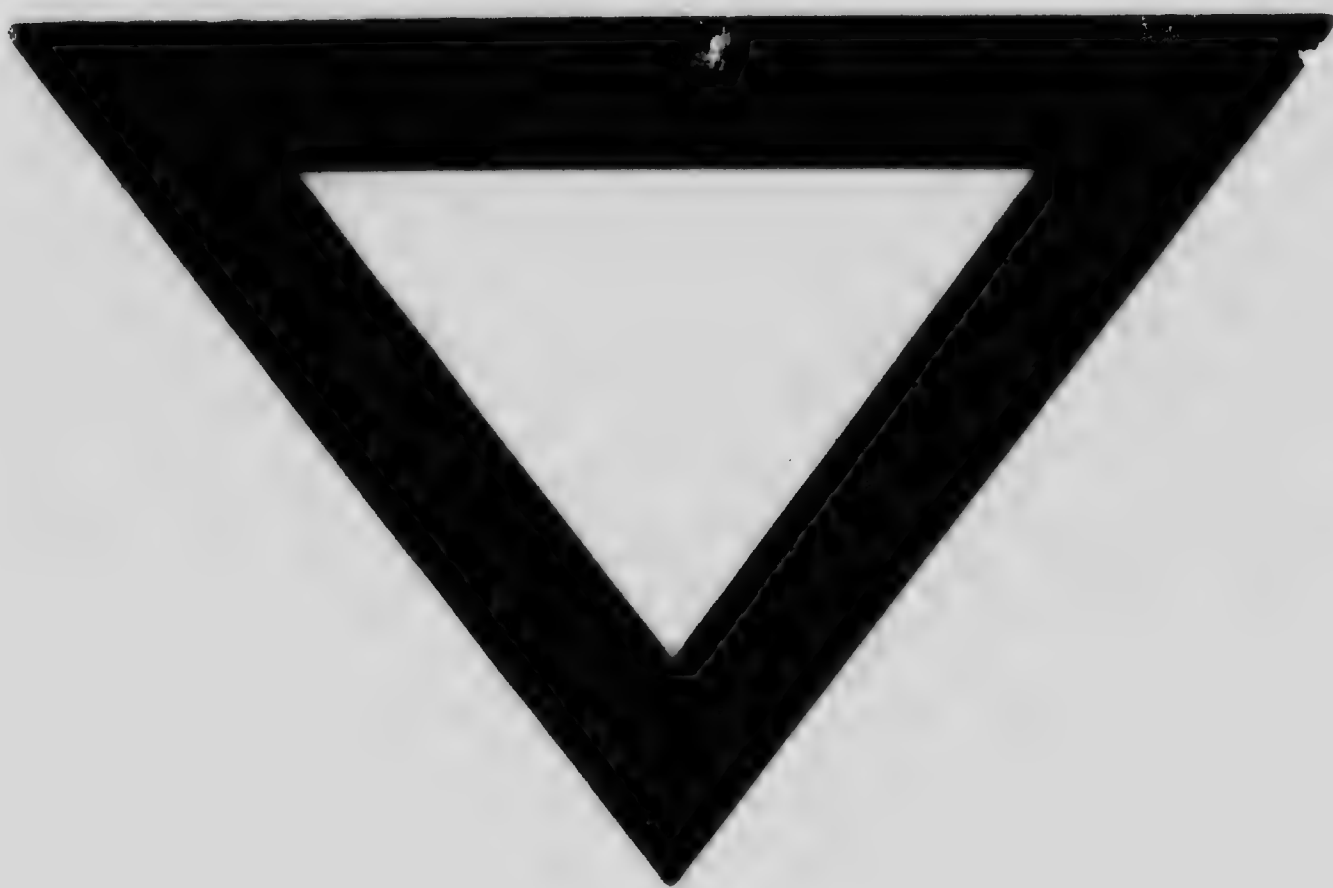
IV. No differentiation of the flours can be made from their protein-content; throughout the series there is no marked departure from the average (12.24 p.c.).

V. The flours of the first three grades give somewhat higher results for gliadin and gliadin ratio than do those of the lower grades. This may point to some relation between maturity and gliadin content, the more fully ripened wheat containing the larger proportion of gliadin. It is significant in this connection that the milling and baking results have led the Cerealist in classifying the wheats to make the first group consist of the three first grades.

VI. The percentages of water-soluble constituents in the flours increase from the first to the last of the series, the increase being chiefly in the nitrogen- and ash-free extract or carbohydrates. This agrees in a measure with the sugar results as obtained from both aqueous and alcoholic solutions, but does not fall into line with the data for the volume of loaf produced. There is here no confirmation of Wood's theory that volume of loaf increases with the percentage of sugar present; indeed the evidence is directly to the contrary. It is, however, only right to add that in this series there may be a disturbing influence from the presence of immature or frosted grain.

The exact nature of the water-soluble carbohydrates of the flours is unknown but is evidently worthy of study. As the volume of loaf is seen to decrease with the increase of this component it seems more than probable that volume is influenced by the amount of soluble constituents, or at all events that such is the case in flours from immature or frosted wheats.

VII. The results of the present series lend some confirmation to Wood's theory that the shape of loaf is influenced by the ratio to the protein (or total nitrogen) of the soluble ash constituents.



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